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AUTHOR Henney, Maribeth
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ABSTRACT

Two related studies were conducted to determine whether students read all-capital text and mixed text displayed on a computer screen with the same speed and accuracy. Seventy-seven college students read M. A. Tinker's "Basic Reading Rate Test" displayed on a PLATO computer screen. One treatment consisted of paragraphs in all-capital type followed by paragraphs in mixed type, then single sentences in capital type followed by sentences in mixed type. In the other treatment, paragraphs still preceded sentences, but regular mixed type preceded all-capital type. Subjects were asked to touch the screen at the word that did not make sense, with response time and accuracy recorded by the computer. In the second study, 47 sixth grade students followed the same experimental design on an Apple II Plus microcomputer, with response time and accuracy measured with a stop watch. The results of the two studies indicated that college students were able to read text written in mixed print faster but less accurately than that written in all capital letters. Sixth graders did not perform differently with either type of print. The differences in accuracy of response between capital and mixed print for both college and sixth grade students indicate a need to consider accuracy as well as response time when testing reading and raise the question of whether speed or accuracy is more important for today's reading demands. (HTH)

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THE EFFECT OF ALL-CAPITAL VS. REGULAR MIXED PRINT, AS PRESENTED ON A COMPUTER SCREEN, ON READING RATE AND ACCURACY

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By Maribeth Henney

Non-standard print is common on newspaper headlines, book titles and traffic signs but as such has had minimal influence on students' reading practices. However, with the growth of the instructional use of microcomputers, students of all ages are being exposed to an increasing amount of non-standard text. The effects of extensive use of this medium on reading practices and development is an important research question.

One of the likely effects of non-standard print is to decrease the legibility of text. Legibility, as defined by Tinker (1964), "deals with coordination of those typographical factors inherent in letters and other symbols, words, and connected textual materials which affect ease and speed of reading." In his studies, he found that the factors which influence the legibility of individual letters include (a) some single part which serves as a distinguishing characteristic for that letter, (b) the area of white space included within the outline of a letter, and (c) size. Lower case letters have more variation in shape or configuration than upper case letters. Since all upper case text is standard on many microcomputers, the lack of configuration clues may degrade the legiblity of computer-presented text.

Numerous studies have been conducted to study the legibility of lower case vs. upper case print (Breland & Breland, 1944; Paterson & Tinker, 1946; Tinker, 1932; Tinker, 1955; Tinker & Paterson, 1928; Tinker & Paterson, 1939; Starch, 1914). Lower case letters and words are perceived at a faster rate than all capitals. The exception was found for reading print at a distance, such as for traffic signs (Tinker, 1932). Distinctive characteristics of lower case letters, the ascending

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and descending strokes, give more clues by which a reader responds. Words written in all capitals present letters which are all the same height and in straight horizontal alignment. The printing surface required for all-capital text is about 35 per cent greater than that for the same material in lower case. This increases the number of fixation pauses required to perceive the material and thus decreases the number of words to be perceived per fixation.

Until recently, nearly all text presented by microcomputers employed only capital letters. Practical and economic technological considerations discouraged common usage of lower case print. Modern innovations, however, open the door for wide spread use of both capital and small letters. This encourages empirical evaluations to determine the advantages and disadvantages of selecting this option.

The Research Study

The purpose of this research was to investigate the speed and accuracy with which children and college students read non-standard text. The specific questions which the study addressed were: (a) Do college students read all-capital text and mixed text as displayed on a computer screen with the same speed and accuracy? and (b) Do elementary school students read all-capital text and mixed text displayed on a computer screen with the same speed and accuracy? By observing the behavior of these two groups and comparing the observations, it was hoped that some insight could be gained to aid in the design and use of computer-based instructional material. In this paper, the study involving college students is described first, followed by the study of elementary students. The discussion and conclusions integrate the two studies.

Study One

Sample

All eighty-eight students from three sections of a reading methods course for elementary education majors agreed to participate in the experiment. These students were primarily college juniors and seniors. Sixty-eight were female and four were male. The students were randomly divided into two experimental groups consisting of 44 students each. A post hoc analysis of the groups using course grades as the criterion indicated that the groups were equivalent, t=.586.

From the 88 participants only 72 sets of data were complete. Four students dropped the course before the experiment began, the data for five students were incomplete and therefore were discarded, and the data for seven students were lost due to hardware problems. Attrition left the two groups containing 34 and 38 students.

Stimulus Materials

The Basic Reading Rate Test, by Tinker, revised by Carver (1971), was programed for computer display. The test presented short situations in one or two sentences in which the student was to identify one word which did not make sense. Material to be read was presented on a PLATO computer terminal screen. Although not a microcomputer, PLATO had lower and upper case print capabilities and thus was appropriate for this study.

In the original Tinker test, unrelated items were written as "paragraphs" of five items each. This format may be confusing since normally paragraphs center around a single idea. It is also atypical of most microcomputer text, where terse comprehensible messages are favored. For these reasons, the test was presented both in "paragraph" form and as individual items.

The test was presented in four sections: (a) all-capitals, paragraphs of five items on the screen at one time; (b) all-capitals, one item on the screen at a time; (c) regular mixed print, paragraphs; and (d) regular mixed print, separate

items. As the text was displayed on the screen, the student read each item, selected the word which did not make sense, and touched the screen at that word. The program moved forward automatically as each paragraph or separate item was completed, whether right or wrong. Each student's responses were monitored individually by the computer, recording the time required to read and respond to each item and the accuracy of the response.

Procedure

It was initially assumed that upper and lower case print as well as the order in which students were exposed to these two types of print could influence the speed and accuracy with which they could read printed material. In order to test these assumptions two treatments were designated. One treatment consisted of paragraphs in all-capital type followed by paragraphs in regular mixed type (capital and lower case), and then sentences (single items) in capital type followed by sentences in regular mixed type. For the other treatment, paragraphs still preceded sentences but regular mixed type preceded all-capital type. The design is diagramed in Table 1.

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Insert Table 1 about here

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Students were given a minimum of background during class about how to operate the computer, how to use the program, and a brief description of what task the program required of them. The objective of the research was not explained. Each student individually worked through the test program. Afterwards he or she completed a personal reaction sheet giving preference for upper or lower case print, and for paragraphs or single item format, as well as reasons for his or her preferences. After all students had finished the assignments, an explanation of the research was given to the classes.

By considering paragraph and sentence data independently, the design was a split-plot with repeated measures. (Kirk, 1968). The non-repeated measurement was the order of presentation (i.e., group 1 or group 2) and the repeated measurement was case (capital or mixed print). Each student completed all four cases, but the order of presentation varied between groups. The data for sentences and paragraphs were analyzed separately using the GLM (General Linear Model) procedure of the Statistical Analysis System. This procedure used the principle of least squares to fit a fixed-effects linear model to the data.

Results

From the data from these groups, four types of analyses were completed: time and accuracy of response for both paragraph and sentence reading. Each of these is examined separately below.

The analysis of response times for paragraph data revealed a significant difference due to case, $F(1,70) = 5.34$, $p<.03$. There were no significant differences attributable to order of presentation or interaction between order of presentation and case. The mean time to process each paragraph was 38.35 seconds for upper case and 37.14 seconds for mixed type. Means and standard deviations by group by case are given in Table 2.

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Insert Table 2 about here

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The results from the analysis of accuracy of response for paragraphs showed a highly significant difference due to case, $F(1,70) = 13.88$, $p<.001$, but no significant difference due to order of presentation or order of presentation and case interaction. The percentage of correct responses was 95.0 for capital paragraphs and 92.4 for mixed type.

Sentence response time followed a similar pattern, although not identical, to the paragraph data. For response times there was a highly significant difference due to case, $F(1,70) = 34.82$, $p<.001$. An inspection of the cell means revealed that students responded more rapidly on the average to mixed type (6.98 sec.) than to capital type (7.34 sec.) There was no difference attributable to order of presentation alone, but a significant difference for the interaction between case and order occurred, $F(1,70) = 9.63$, $p<.003$. In both groups the mixed type was read more rapidly than the capital type but for the group receiving mixed type first the difference was much greater.

The sentence accuracy data analysis failed to reveal any significant differences due to case, order of presentation, or interaction of case and order.

An analysis of the subjective data obtained from the students' reaction papers completed after they had done the test on the computer indicated that twice as many students preferred reading the regular mixed type as preferred capitals. Three-fourths preferred the presentation of material as single items rather than as paragraphs.

Study Two

Sample

Forty-seven sixth grade students from a rural Iowa elementary school participated in this experiment. The children were from two classrooms and constituted the entire sixth grade population from the district. There were 24 males and 23 females. Random assignment of students was made to two experimental groups.

Stimulus Materials

The Tinker test used in study one was also used in this study. It was typed into an Apple II Plus microcomputer and stored on a disk. Since the Apple hardware did not have small letter capability, a special lower case program was used for

displaying the text of the test (Throop, 1981). For this study, the paragraphs consisted of only four items each. Otherwise, the format of materials, including the combination of paragraphs, sentences, regular mixed print and all-capital print, was identical to study one.

Procedure

The experimental design was the same as used in study one. Each child saw paragraphs in both all-capital and mixed print and then single items in all-capital and mixed print for a total of four treatments. Each treatment consisted of 24 items on which response time and accuracy were recorded. One group of students received the all-capital print first while the other group received the mixed print first.

Each child individually completed the testing, working with the researcher. The time lapse for each item between item presentation and student response was measured with a stop watch. The times for the 24 items in each treatment were added to produce the treatment response time. The accuracy score for each treatment consisted of the number of items answered correctly.

Results

The response time for paragraph data failed to produce a significant difference in order of presentation or case. However a significant order-case interaction was observed, $F(1,45) = 7.43$, $p<.01$. An inspection of the means revealed a decrease in reading speed as the student progressed through the paragraph text. This may have been due to the initial instructions students were given, to read as rapidly and accurately as possible. By the second set of text the students may have reverted to their natural speed. The students receiving regular mixed print text first followed by all-capitals increased in reading time from 360 seconds to 384 seconds, whereas those receiving all-capitals first increased from 367 to 388 seconds. The means and standard deviations are shown in Table 3.

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Insert Table 3 about here

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The analysis of accuracy data for paragraphs revealed a pattern identical to the response time analysis. No significant differences due to order of presentation or case were observed. However, a significant order-case interaction, $F(1.45) = 7.75$, $p.<01$, did exist. An inspection of the means revealed that greater accuracy accompanied increased reading speed. Students encountering all-capital print first correctly identified 22.65 of the 24 words whereas, on the second set consisting of regular mixed print, they correctly identified 22.13. Students encountering mixed print first scored 22.88 while scoring 22.08 on the all-capital set.

No significant differences were found in the analysis of reading time for the sentences due to order of presentation or due to case. As in the paragraph analysis, there was an order-case interaction, $F(1.45) = 4.97$, $p<.03$; however it was inconsistent with the paragraph findings. For sentences, the last viewed set was read most rapidly. The group receiving all-capitals first had a time for all-capital text of 310 seconds and for mixed print of 296 seconds. Those receiving mixed print first required 308 seconds and dropped to 297 seconds for the all-capital text.

Accuracy data for sentences contained no significant differences due to order or case and no significant order-case interaction. Unlike paragraph data the decrease in reading speed was not accompanied by a decrease in accuracy.

Discussion

The type of print used on the screen did make a difference for college students. They were able to read text written in mixed print faster but less accurately than that written in all-capitals. Sixth graders did not perform differently with either type of print. Apparently they read all-capital text in the same way they read mixed print.

Tinker (1964, p. 4) concluded that the mechanics of reading become stabilized, or like that of adults, somewhere between the fourth and the eighth grade. His conclusion was based on two studies of oculomotor movements (Buswell, 1937; Ballantine, 1951). Rayner (1976) clarified this view in finding that kindergarteners through second graders relied heavily on the first letter in word recognition tasks. Such reliance leveled off between second and fourth grades, and began to decrease in fifth grade. He concluded that word shape was a more important cue with increasing age and ability. This developmental change in word identification strategies was also supported in studies by Timko (1970); Williams, Blumberg, and Williams (1970); Williams (1977); and Terry (1976). These studies showed that configuration is an ineffective and seldom used cue in word recognition for children but that adults do use overall shapes of words.

These research studies give support to the findings of the present study, in which adult readers read mixed print faster than all-capital print but sixth graders read either type with equal speed. The sixth graders apparently tended to decode words by examination of letter-sound correspondence more than they did by configuration. This may be a factor of their reading development level, as the above research studies implied. It might also be a result of a heavy emphasis on phonics and structural analysis in today's schools, leading children to overanalyze words which could be more rapidly read as whole sight words (Harris, 1980, p. 564).

The differences in accuracy of response between capital and mixed print for both college and sixth grade students indicate a need to consider accuracy as well as response time when testing reading. This differs from Tinker's report of a 99.7 average percentage accuracy for college students' performance on the Basic Reading Rate Test, and contradicts his conclusion that scoring the number of items attempted was sufficient and could be substituted for the number correct score (1964, p. 21). Tinker's results were based on a paper printed test. Reading a computer screen may be different, resulting in more errors. In any case, accuracy of reading

computer-based material should be considered when determining factors influencing rate.

Although the college students read mixed print significantly faster than all-capitals, for the paragraph reading they were significantly more accurate when reading all-capitals. Tinker (1932) found that, for reading single words, word form was more important for perception of lower case words than for upper case words, but lower case yielded more misreadings. Words of similar configuration were frequently confused. When reading all-capital words, perception apparently involved examination of words letter by letter, not by configuration, thus leading to less confusion of words. It may be possible that these findings are applicable to reading full sentences as well. Since reading all-capital paragraphs necessitated letter by letter examination of words, the reading rate was retarded, but due to the fact that words were not being decoded as wholes with the aid of configuration clues, less confusion of words similar in form occurred, leading to greater accuracy. Although differences were not significant for reading single items, there was a slight edge in accuracy for reading all-capitals in this treatment as well.

The question must be raised as to which is more important as a goal for reading, accuracy or speed. Accuracy is essential, but speed is needed in today's world to deal with all that must be read daily. Since all-capital print leads to greater accuracy but a slower rate, apparently a choice must be made. The limited data of this study, however, does not provide a strong enough base upon which to make such a choice. Many other factors of legibility need to be considered as well. One factor definitely would be that of fatigue in reading. Extended reading of all-capital text possibly might be more tiring than reading mixed print, due to the added concentration needed to decode words letter by letter. Further research is needed to evaluate the visual fatigue of all-capital vs. mixed print reading.

Subjective reports of Tinker's subjects (1950; Paterson and Tinker, 1940, 1942) showed that 90 per cent of the college students involved in these studies preferred lower case print. This "pleasingness rating (Tinker, 1964, p. 57)" would be related

to visual fatigue. It seems people would prefer to read what was easiest to read. In the present study, 67 per cent of the college students stated a preference for reading mixed print. Although this is somewhat lower than Tinker's percentage, the direction of preference is definitely the same. The sixth graders gave a preference for all-capitals, stating that the letters were bigger and easier to see.

Conclusions

The results of this study do not discourage the continued use of all-capital text for reading by children. Factors such as the effect of extensive exposure to all-capital text on students' acquisition of the use of configuration clues to aid flexibility in reading rate were not considered. With adult readers it appears that speed of reading can be increased through the use of mixed print. Furthermore, if the mixed print messages are relatively short, loss of accuracy can be avoided.

In terms of computer-presented text, the layout all too often appears to be designed by the computer specialist, with consideration primarily for the technology rather than for the user. Users often accept formats, print types, glare, etc. which are anything but legible, assuming these are characteristic of the particular medium being used. Many times, however, adjustments could readily be made to improve legibility. Research must be conducted to delineate exactly what specifications of factors will lead to greatest legibility for reading from a computer screen. Then technologists and program designers must employ these techniques to improve user comfort and effectiveness while reading.

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REFERENCE NOTE

Permission was granted by Carver to use the Basic Reading Rate Test for this study. Personal letter, Sept. 26, 1980.

TABLE 1

Treatment Design

Group 1	CP	MP	CS	MS
Group 2	MP	CP	MS	CS

(C = capital type S = sentence form)

(M = mixed type P = paragraph form)

Table 2

Means and Standard Deviations by Group by Case for College Students

Group Case	PAR[a]	SEN	PAC	SAC
Capitals 1st				
Capitals	36.51(10.03)	6.99(1.68)	.964(.040)	.938(.064)
Mixed	35.54(9.62)	6.82(1.66)	.929(.066)	.919(.080)
Mixed 1st				
Capitals	39.99(8.68)	7.66(1.75)	.938(.057)	.917(.101)
Mixed	38.57(9.19)	7.13(1.69)	.920(.075)	.915(.099)

[a]PAR = average time in seconds to read paragraphs of 5 items each

SEN = average time in seconds to read single items

PAC = per cent correct for paragraphs

SAC = per cent correct for single items

Table 3

Means and Standard Deviations by Group by Case

for Sixth Graders

Group Case	PAR[a]	SEN	PAC	SAC
Capitals 1st				
Capitals	367.65(117.99)	309.91(93.49)	22.65(2.29)	22.78(2.26)
Mixed	388.65(130.39)	296.00(92.46)	22.13(2.65)	22.91(2.33)
Mixed 1st				
Capitals	384.63(119.39)	296.63(94.02)	22.08(1.89)	22.96(1.63)
Mixed	360.50(111.80)	308.04(94.64)	22.88(1.80)	23.00(1.29)

[a]PAR = average time in seconds to read 24 items as 6 paragraphs

SEN = average time in seconds to read 24 items as single items

PAC = average number correct in 24 items as paragraphs

SAC = average number correct in 24 items as single items